

Middlesex University Research Repository

An open access repository of
Middlesex University research

<http://eprints.mdx.ac.uk>

Jarvis, Paul ORCID logoORCID: <https://orcid.org/0000-0003-3259-853X>, Cassone, Natasha, Turner, Anthony N. ORCID logoORCID: <https://orcid.org/0000-0002-5121-432X>, Chavda, Shyam ORCID logoORCID: <https://orcid.org/0000-0001-7745-122X>, Edwards, Michael and Bishop, Chris ORCID logoORCID: <https://orcid.org/0000-0002-1505-1287> (2019) Heavy barbell hip thrusts do not effect sprint performance: an 8-week randomized–controlled study. The Journal of Strength & Conditioning Research, 33 . S78-S84. ISSN 1064-8011 [Article] (doi:10.1519/JSC.0000000000002146)

Final accepted version (with author's formatting)

This version is available at: <https://eprints.mdx.ac.uk/22242/>

Copyright:

Middlesex University Research Repository makes the University's research available electronically.

Copyright and moral rights to this work are retained by the author and/or other copyright owners unless otherwise stated. The work is supplied on the understanding that any use for commercial gain is strictly forbidden. A copy may be downloaded for personal, non-commercial, research or study without prior permission and without charge.

Works, including theses and research projects, may not be reproduced in any format or medium, or extensive quotations taken from them, or their content changed in any way, without first obtaining permission in writing from the copyright holder(s). They may not be sold or exploited commercially in any format or medium without the prior written permission of the copyright holder(s).

Full bibliographic details must be given when referring to, or quoting from full items including the author's name, the title of the work, publication details where relevant (place, publisher, date), pagination, and for theses or dissertations the awarding institution, the degree type awarded, and the date of the award.

If you believe that any material held in the repository infringes copyright law, please contact the Repository Team at Middlesex University via the following email address:

eprints@mdx.ac.uk

The item will be removed from the repository while any claim is being investigated.

See also repository copyright: re-use policy: <http://eprints.mdx.ac.uk/policies.html#copy>

Heavy Barbell Hip Thrusts Do Not Effect Sprint Performance: An 8-Week Randomized–Controlled Study

AUTHORS:

Paul Jarvis (MSc), Natasha Cassone (MSc), Anthony Turner (PhD, CSCS*D), Shyam Chavda (MSc, CSCS), Mike Edwards (MSc), and Chris Bishop (MSc)

AFFILIATIONS:

School of Science and Technology, Middlesex University, London Sport Institute, UK

CORRESPONDING ADDRESS:

Name: Chris Bishop

Email: C.Bishop@mdx.ac.uk

Address: 6 Linden Rise, Warley, Brentwood, Essex, CM14 5UB, UK

ABSTRACT

The purpose of this study was to examine the effects of an 8-week barbell hip thrust strength training program on sprint performance. Twenty-one collegiate athletes (15 males and 6 females) were randomly assigned to either an intervention ($n = 11$, age 27.36 ± 3.17 years, height 169.55 ± 10.38 cm, weight 72.7 ± 18 kg) or control group ($n = 10$, age 27.2 ± 3.36 years, height 176.2 ± 7.94 cm, weight 76.39 ± 11.47 kg). 1RM hip thrust, 40m sprint time, and individual 10m split timings: 0-10, 10-20, 20-30, 30-40m, were the measured variables; these recorded at both the baseline and post testing time points. Following the 8-week hip thrust strength training intervention significantly greater 1RM hip thrust scores for the training group were observed ($p < 0.001$, $d = 0.77$ [mean difference 44.09 kg]), however this failed to translate into changes in sprint time for any of the measured distances (all sprint performance measures: $p > 0.05$, $r = 0.05 - 0.37$). No significant differences were seen for the control group for 1RM hip thrust ($p = 0.106$, $d = 0.24$ [mean difference 9.4 kg]) or sprint time (all sprint performance measures: $p > 0.05$, $r = 0.13 - 0.47$). These findings suggest that increasing maximum hip thrust strength through use of the barbell hip thrust does not appear to transfer into improvements in sprint performance in collegiate level athletes.

Key Words: Strength Training, Sprint, Hip Thrust, Posterior Chain

INTRODUCTION

Sprint performance is considered a major determinant of high-level sporting performance, and has additionally been shown to dictate starting position in team sports such as soccer (20) and rugby (17). Considerable research to date has found strong relationships between lower body strength and sprint performance (see review by Seitz et al. [32]). Within the early phases of acceleration, the ability to orientate the resultant ground reaction force (GRF) application to that of a horizontal nature has been strongly correlated to 100m sprint performance (24,25,26,30). Additional research illustrates horizontal forces exceeding those of a vertical nature throughout the ground contact phase of acceleration (546N vs. 431N; Mero, [22], as cited in Cronin & Hansen, [14]), highlighting the importance of horizontal GRF within the early phases of sprint running.

The importance of the hip extensors, more specifically the gluteus maximus, plays a central role in the stabilization of the hips and spine, while assisting in force production throughout hip extension (15,24,25,26). One exercise which has gained popularity for its proposed effectiveness in maximally activating the gluteus musculature is the barbell hip thrust (8,10). As detailed by Contreras et al. (8,9), this exercise demands high levels of gluteal muscle activation, with literature reporting larger electromyography (EMG) amplitudes in the gluteus maximus throughout the barbell hip thrust in comparison to the back squat, hex bar deadlift, and barbell deadlift (1,9).

To the authors' knowledge, a limited sample of literature to date has investigated the effects of the barbell hip thrust exercise on athletic performance measures. Mendiguchia et al. (21) conducted a 7-week neuromuscular training intervention consisting of two training sessions per week. Whilst improvements in 5m sprint time were noted, due to the nature of the training intervention encompassing aspects of eccentric exercises, plyometric exercises, and acceleration exercises, no conclusive evidence as to the sole implications of the hip thrust on performance measures can be attributed. Similarly, research by Rivière et al. (31), Meylan et al. (23), Brown et al. (5), and Cholewa et al. (6) completed training interventions, inclusive of the barbell hip thrust; however, due to the nature of the interventions incorporating a variety of additional training exercises which have been shown to enhance sprint performance, no definitive conclusions can be drawn as to its efficacy as a training tool. On the contrary, research by Zweifel et al. (36) conducted a pilot study comparing the efficacy of the barbell hip thrust in comparison to the squat and deadlift in experienced lifters. Most notable from their results was of how the barbell hip thrust (when compared to their control

group) identified large effect-sizes ($r \geq 0.5$) for broad jump, 40-yard sprint, and 3RM hip thrust strength following a 6-week training intervention, highlighting a potential link between the barbell hip thrust and increases in sprint performance. Similarly, Contreras et al. (10) also identified potential benefits of the hip thrust when compared to the front squat. Notably, results identified increases in sprint performance (10m and 20m), isometric mid-thigh pull strength, and hip thrust 3RM strength following a 6-week training intervention, with their results highlighting a link with the concept of force application specificity (i.e. anteroposterior force application) when programming for increases in sprint performance. Whilst Contreras et al. (10) did identify improvements following the hip thrust, it should be noted that participants were youth athletes (aged 14 - 17), and while they all had one year's experience squatting, no prior experience with the hip thrust was noted. Therefore, caution should be applied when interpreting these results, as it is plausible that any reported changes may be partially attributed to a learning effect associated with a new exercise.

Seitz et al. (32) identified the back-squat exercise as lending itself to the greatest mean improvements in sprint time ($3.33 \pm 2.33\%$) in comparison to exercises of a more ballistic nature (e.g. loaded jump squat/countermovement jump); however, possible drawbacks have been noted. For example, a study by Contreras et al. (9) compared surface EMG activity of the gluteus maximus (upper and lower), biceps femoris, and vastus lateralis within both the back squat (~10 repetition maximum [RM]) and barbell hip thrust (~10RM). Interestingly, the barbell hip thrust accrued significantly greater EMG amplitudes for all the hip extensor muscles throughout the ~10RM set (upper gluteus maximus, lower gluteus maximus, biceps femoris), with only the vastus lateralis producing higher amplitudes within the back squat. Moreover, the back squat is primarily a sagittal plane movement, and thus lacks specificity of anteroposterior force application noted within sprinting (35). As such, it appears prudent to postulate how a hip dominant exercise such as the barbell hip thrust, trained longitudinally, may lend itself to faster sprint times by maximally activating the gluteus musculature to a larger extent than the back squat (1,9), whilst challenging force application of an anteroposterior nature (35). Thus, further research into the training implications of the barbell hip thrust on sprint performance is warranted.

Therefore, the aim of this study is to examine the effects of an 8-week barbell hip thrust strength training program on sprint performance. The authors hypothesize that: 1) the barbell hip thrust will lead to an increase in maximum hip thrust strength, 2) the barbell hip thrust will lead to increased sprint acceleration performance over 10m, due to the demands of horizontal GRF, and 3) the barbell hip thrust will lead to improvements in overall 40m sprint time.

METHODS

Experimental Approach to the Problem

A case-control study design was used to investigate the effects of an 8-week barbell hip thrust strength training intervention on sprint performance over a 40m distance and 1RM hip thrust strength. Performance variables were measured both at baseline (week 1), and following either an 8-week barbell hip thrust strength training intervention comprising of 16 training sessions, or no hip thrust training, group dependent (week 10).

Subjects

A total of 21 collegiate athletes, comprising of 15 males and 6 females, volunteered to participate in this study. Athletes were randomized into either an intervention ($n = 11$, age: 27.36 ± 3.17 years, height: 169.55 ± 10.38 cm, weight: 72.7 ± 18 kg) or control group ($n = 10$, age: 27.2 ± 3.36 years, height: 176.2 ± 7.94 cm, weight: 76.39 ± 11.47 kg). Statistical analysis (t -test) was run to confirm that the groups were evenly distributed and that no significant differences were observed between any of the baseline variables ($p > 0.05$ for all measures). Inclusion criteria stipulated that a one-year minimum resistance training experience was required, inclusive of the barbell hip thrust, and participants had to be free from injury at the commencement of the testing period. Ethical approval was granted by the London Sport Institute Ethics Committee, Middlesex University.

Procedures

The present study was completed over a 10-week period. All performance testing and training sessions were conducted within a performance laboratory, and participants were asked to refrain from participating in any strenuous exercise on the days leading up to testing sessions. Throughout week one all participants, upon arrival to the performance laboratory, completed informed consent and health screening questionnaires. Participants were familiarized to the experimental conditions,

whereby the barbell hip thrust exercise (3 x 10 repetitions at self-selected load) and maximal sprints (5 x 40m) were conducted. A minimum of 48 hours following this, baseline data for each of the dependent variables was collected (40m sprint and 1RM hip thrust). Participants were then randomly allocated into either the hip thrust training group or the control group. Weeks 2-9 saw the completion of the training intervention, whereby participants either completed the hip thrust exercise as outlined below (see “Hip Thrust Strength Training Intervention”) or acted as a control group, whereby no strength training throughout the time period was conducted. Throughout the 8-week intervention period, all participants were instructed to continue with their ordinary activity levels, irrespective of group allocation. Week 10 comprised of post testing data collection, whereby values were recorded for the dependent variables measured (40m sprint and 1RM hip thrust).

40m Sprint Testing

40m sprint testing required participants to perform three 40m maximal sprints on an outdoor third generation (3G) playing surface. Sprints were separated by a 3-minute passive rest period. Infrared timing gates (*Brower, Wireless TC Timing System, Draper, UT, USA*) were used to record both split times: 0-10, 10-20, 20-30, 30-40m, and overall 40m sprint time. These intervals have previously been considered appropriate to assess the three phases of a sprint: acceleration, attainment of maximal velocity and maintenance of maximal velocity (15). All participants started in a staggered stance with their preferred foot leading and were instructed to perform all sprints with maximal intent, with this process repeated throughout for consistency. Standard training shoes were permitted; however, to remain consistent participants were required to wear the same footwear for both testing sessions (pre and post intervention time points).

1RM Hip Thrust Testing

1RM barbell hip thrust load was measured following a standardised protocol, with all participants permitted 3–6 attempts undergoing 2.5% increments until 1RM was achieved (2). All hip thrusting was conducted in accordance with the protocol guidelines as proposed by Contreras et al. (8). Before the start of the warm-up, end range was assessed using a goniometer (90° angle at the knee and neutral alignment of hips; see guidelines by Contreras et al. [8]), whereby participants completed an unweighted hip thrust. An elastic band was subsequently placed at the appropriate height so that the participant’s hips achieved neutral throughout each repetition. This was

1 additionally reinforced through verbal commands. Maximal intent throughout the concentric phase
2 of the lift was encouraged. Participants were required to hold the fully extended position for a 1-
3 second count, before a controlled eccentric phase to return the barbell to the ground was
4 permitted. Participants rested for a minimum of five minutes between trials until 1RM maximal
5 load was achieved.

6 7 *Hip Thrust Strength Training Intervention*

8 The hip thrust training intervention was completed between weeks 2-9 (8-week period) and was
9 solely performed by the training group. Participants performed the hip thrust exercise twice per
10 week following a loading strategy of 5 sets of 5 repetitions, with load equated at 85% of their
11 baseline 1RM (29). A 3-minute rest period between sets was permitted. All training sessions were
12 conducted on the same days within the week for each individual, and all sessions were divided by
13 72-hours. In line with a 1RM protocol, load was progressively increased by 2.5% once participants
14 were able to complete two more repetitions than the repetition goal in the final set during two
15 consecutive sessions. As proposed by Contreras et al. (10), to limit interference of additional
16 strength exercises on potential training adaptations (16), the hip thrust was the sole training
17 exercise permitted over the training period. In order for data to be accepted, 100% training
18 adherence was required. Throughout all training sessions, athletes were under supervision by a
19 strength and conditioning coach.

20 21 *Statistical Analyses*

22 Descriptive statistics were calculated and reported as mean \pm standard deviation (SD). To assess for
23 normality, a Shapiro-Wilk test was used; where $p < 0.05$, non-parametric data analysis was
24 computed. Where $p > 0.05$, parametric data analysis was conducted. Absolute reliability within
25 sprint based tests was computed through the coefficient of variation (CV). Relative reliability within
26 sprint based tests was computed through the intraclass correlation coefficient (ICC), detecting for
27 absolute agreement in both score and rank. Due to only a single score attained at each time point
28 for 1RM hip thrust, reliability was determined solely through consistency in rank order as opposed
29 to absolute agreement in scores also, with this analogously computed using the ICC. For normally
30 distributed data, a (2 x 2) repeated measures ANOVA (condition [intervention vs control] and time
31 [pre vs post]) was computed, with Bonferroni correction post hoc analysis run to determine, where

necessary, which measures significantly differed. For parametric data analysis, effect size was reported using Cohen's d , with 0.2, 0.5, and 0.8 indicative of a small, moderate, and large effect respectively (7). To assess for differences within non-normally distributed data, a Wilcoxon signed-rank test was used. Effect size was subsequently reported using Pearson's r , with 0.1, 0.3, and 0.5 indicative of a small, moderate, and large effect respectively (7). Statistical significance was accepted at 95% ($p < 0.05$). Mean percentage change (Δ) from pre to post time points was reported, whereby a positive percentage change is indicative of an increase in sprint time and thus reduced sprint performance, and a negative percentage change implying a decrease in sprint time and thus a faster sprint. All statistical analysis was performed using SPSS software (*Version 20, IBM, Armonk, NY, USA*).

RESULTS

All 21 athletes who volunteered to partake in this study adhered to the demands of the training intervention (hip thrust vs. no hip thrust); thus, providing complete data sets (pre vs. post time points) for both the hip thrust training intervention group ($n = 11$) and the control group ($n = 10$) (see Table 1).

*** INSERT TABLE 1 ABOUT HERE ***

All variables of sprint time were identified as non-normally distributed; 0-10 ($p < 0.001$), 10-20 ($p < 0.001$), 20-30 ($p < 0.001$), 30-40 ($p < 0.001$), and 40m ($p < 0.001$); thus, non-parametric data analysis was computed, with effect size reported as Pearson's r . Hip Thrust 1RM was identified as normally distributed ($p = 0.592$); thus, parametric data analysis was computed, with effect sizes reported as Cohen's d . All measures of sprint time attained at the baseline time point reported high levels of both absolute reliability ($CV = 1\text{--}3.3\%$), and test-retest reliability (see Table 2), with ICC values reporting almost perfect agreement ($ICC = 0.911\text{--}0.996$). Hip thrust 1RM reported high levels of rank order consistency for test-retest reliability for both the intervention group ($ICC = 0.93$, 95% CI: 0.762-0.981) and control group ($ICC = 0.955$, 95% CI: 0.831-0.989).

*** INSERT TABLE 2 ABOUT HERE ***

Control Group

Over the 8-week intervention period, the control group saw no meaningful improvements in any of the split timings for sprint performance; 0-10m ($\Delta = 0.19\%$, $p = 0.68$, $r = 0.13$), 10-20m ($\Delta = 1.51\%$, $p = 0.13$, $r = 0.47$), 20-30m ($\Delta = 2.15\%$, $p = 0.17$, $r = 0.44$), 30-40m ($\Delta = -0.76\%$, $p = 0.37$, $r = 0.28$). Additionally, no significant improvements in overall 40m sprint performance were noted ($\Delta = 0.89\%$, $p = 0.38$, $r = 0.27$).

Hip Thrust Intervention Group

Similar to the control group, no meaningful improvements were noted for any of the split timings for sprint performance; 0-10m ($\Delta = 3.92\%$, $p = 0.44$, $r = 0.23$), 10-20m ($\Delta = -0.76\%$, $p = 0.22$, $r = 0.37$), 20-30m ($\Delta = -0.24\%$, $p = 0.76$, $r = 0.09$), 30-40m ($\Delta = 0.51\%$, $p = 0.86$, $r = 0.05$). Furthermore, no significant improvements in overall 40m sprint performance were identified ($\Delta = 0.88\%$, $p = 0.42$, $r = 0.24$).

1RM Hip Thrust

ANOVA identified a significant interaction effect of condition (intervention vs. control) and time (pre vs. post) [$F_{(1,19)} = 20.497$, $p < 0.001$, $d = 0.519$]. Post hoc analysis identified significantly greater 1RM hip thrust scores for the intervention group at the post testing time point (see Figure 1) when compared to baseline ($p < 0.001$, $d = 0.77$ [mean difference 44.09 kg]). No significance was seen for the control group (see Figure 2), when compared to its respective baseline measure ($p = 0.106$, $d = 0.24$ [mean difference 9.4 kg]).

*** INSERT FIGURES 1 AND 2 ABOUT HERE ***

DISCUSSION

The present study set out to determine the sole use of the barbell hip thrust over an 8-week strength training period, in an attempt to augment sprint performance. It was hypothesized that the training intervention would lend itself to both increases in maximum hip thrust strength, but also transfer to increases in sprint performance. While previous studies have widely found noteworthy improvements in sprint velocities with lower body strength developments (see review

by Seitz et al. [32]), the findings of the present study appear to oppose such evidence. Within the present study, a moderate training effect for the barbell hip thrust on 1RM hip thrust strength was noted ($d = 0.77$), however this failed to translate into increases in sprint performance, with no meaningful improvements in any of the split timings ($r = 0.05 - 0.37$) or overall 40m sprint performance ($r = 0.24$) noted following the strength training intervention. These findings suggest that heavy barbell hip thrusts do not facilitate sprint performance following an 8-week strength training period in a sample of collegiate athletes.

A moderate within-group training effect was noted for 1RM hip thrust strength following the 8-week training intervention, with group mean values illustrating a pre to post change of 44.09kg. This data falls in line with previous research, for example by Crewther et al. (12), who suggests heavy strength training loads (85-100% 1RM) to induce optimal increases in strength, this achieved through neural mechanisms, for example through enhanced neural coordination. To load the athletes within the present study, 85% of 1RM was used, with load increased by 2.5% once participants could complete two more repetitions than the repetition goal in the final set during two consecutive sessions (29). Research by Contreras et al. (10) undertook a different approach, whereby participants were loaded over a 6-week period, with loads starting at 12RM (week 1) and ending at 6RM (week 6). Interestingly, Contreras et al. (10) identified moderate effects between groups at the post testing time point, with results favoring the hip thrust over the front squat for both 10m ($d = 0.32$) and 20m ($d = 0.39$) sprint times. Similarly, a recent pilot study by Zweifel et al. (36) acknowledged improvements in sprint performance with strong effect sizes noted following a 6-week training intervention period, with loads ranging from 30% to 100% of each athletes 1RM. This raises the question therefore as to optimal loading strategies to enhance sprint performance within the hip thrust exercise, questioning as to whether reduced intensity loading strategies (6-12RM) may in fact be more favorable for the hip thrust exercise. Previous research has noted peak power to occur at approximately 56% 1RM within the back squat exercise (11). Whilst it can be argued of the vast kinematic dissimilarities of the back squat to the hip thrust, the principle of sub-maximal loads to ascertain peak power must be noted. In this instance, Contreras et al. (10) used 60% 3RM within week 1, this most likely closer to each individuals peak power threshold, and thus velocity transference to sprint running may have been greater. With this in mind therefore, further

research in this area is warranted to greater understand loading strategies and their transference to sprint performance within the barbell hip thrust exercise.

Further mechanisms thought to have affected the findings of the present study are the variability of sprint mechanics seen within untrained athletes regarding level of prior technical sprint training. An individual's ability to sprint is heavily determined by multiple facets such as stiffness upon ground contact, stretch shortening cycle capabilities, ground contact time, stride length, stride frequency, recruitment of additional musculature (3,15,19,28). The athletes in the present study were adult collegiate level athletes, this in comparison to adolescent athletes used by Contreras et al. (10) who were enrolled within either the New Zealand rugby or rowing athlete development programs. This variability in sprint performance may be part explained from a study by Bradshaw et al. (4). The authors investigated the movement variability within sprint trained athletes (aged 17 – 23 years, 100m personal best: 10.87 ± 0.36 s), assessing biological movement variability within the start and early acceleration phases of a sprint. Most interesting from their findings was of how individual variability within start position angular kinematic parameters, reported through the coefficient of variation (CV), was reported to be as high as 24.54%. Within the present study, no measure of the process used to complete the sprint was attained (i.e. kinematic variables), solely the outcome of the sprint (i.e. sprint time) was measured. However, to standardise the start position within the present study (due to its implications on kinematic parameters within early acceleration [4]), participants were required to start each trial in a staggered stance with their preferred foot leading, and this was consistent throughout the testing process to confine such issues. Nonetheless, considerations for alterations in kinematic parameters should be noted, highlighting considerations for future research.

A potential limitation to be noted within the present study is of how both males and females were recruited. Although gender differences in sprint performance have received limited attention (13), males are generally seen to have a higher absolute and relative power output than females (18), and typically longer lower limbs (33). This information may suggest shorter stride lengths within females compared to males, which as such may contribute to slower sprint speeds. The present study corroborates with such results, with males identifying faster sprint times than females at the baseline time point (males: 5.78 ± 0.68 s vs. females: 6.62 ± 1.5 s). Further to this, whilst similar

changes were seen across the intervention following the barbell hip thrust for both males (5.78 ± 0.68 s pre to 5.83 ± 0.54 s post) and females (6.62 ± 1.5 s pre to 6.62 ± 1.27 s post), the disparity in genders by virtue of the deviance in scores may in turn increase the standard deviation of the data, which as such may mask any statistically true change from pre to post training intervention. To negate such issues however within data analysis, all data for sprint time was reported as individual percentage change from pre to post testing time points. Future research however could look to explore this concept further, given the implications of posterior chain development within female athletes on both injury and performance (27). Additionally, a lack of more complex metrics (due to the limited access to expensive equipment), for example a force plate to measure kinetic variables such as peak force/rate of force development (RFD), or 3D motion capture to derive kinematic variables, hinders the ability to generalise the findings of the present study outside the scope of outcome measures (i.e. 40m sprint time and hip thrust 1RM), as opposed to the process carried out to achieve this (i.e. kinematic parameters, force-time characteristics).

PRACTICAL APPLICATIONS

The present study set out to examine the effects of a heavy barbell hip thrust on sprint performance over an 8-week training period in a sample of collegiate athletes. While previous studies have identified increases in speed and acceleration performance following use of the barbell hip thrust (10,36), the findings of the present study do not appear to support such evidence. It appears therefore that the usefulness of heavy barbell hip thrusts to enhance sprint performance remains questionable. These findings, combined with those of Contreras et al. (10), may suggest how 6–12RM loads may be more favorable in attaining increases in sprint performance, perhaps due to a greater velocity transference to sprinting. As such, further research is warranted, with specific importance on loading intensities and their transference to sprint performance. Furthermore, comparison between the barbell hip thrust and the back squat following a training intervention is necessary, due to greater absolute loads attainable in the back squat compared to the front squat (as seen by Yavuz et al. [34]), thus theoretically leading to a superior training adaptation from a force application perspective, but also due to the high correlations with back squat strength and sprint performance (32).

1 REFERENCES

- 2 1. Andersen, V, Fimland, MS, Mo, DA, Iversen, VM, Vederhus, T, Rockland Hellebø, LR,
3 Nordaune, KI, & Saeterbakken, AH. Electromyographic Comparison Of Barbell Deadlift, Hex
4 Bar Deadlift And Hip Thrust Exercises: A Cross-Over Study. *J Strength Cond Res.* (Published
5 Ahead of Print). doi: 10.1519/JSC.0000000000001826.
- 6 2. Baechle, TR, Earle, RW, & Wathen, D. Resistance training. In: Essentials of Strength Training
7 and Conditioning. T.R. Baechle and R.W. Earle, eds. Champaign, IL: Human Kinetics. pp. 381–
8 412. 2008.
- 9 3. Baker, D, & Nance, S. The Relation Between Running speed and Measured of Strength and
10 Power in Professional Rugby League Players. *J Strength Cond Res.* 13: 230-235. 1999.
- 11 4. Bradshaw, EJ, Maulder, PS, & Keogh, JW. Biological movement variability during the sprint
12 start: Performance enhancement or hindrance? *Sports Biomech.* 6: 246-260. 2007.
- 13 5. Brown, SR, Feldman, ER, Cross, MR, Helms, ER, Marrier, B, Samozino, P, & Morin, JB. The
14 Potential for a Targeted Strength Training Programme to Decrease Asymmetry and Increase
15 Performance: A Proof-of-Concept in Sprinting. *Int J Sports Physiol Perform.* 1-13. 2017.
- 16 6. Cholewa, JM, Rossi, FE, MacDonald, C, Hewins, A, Gallo, S, Micenski, A, Norton, L, &
17 Campbell, BI. The effects of moderate-versus high-load resistance training on muscle
18 growth, body composition, and performance in collegiate women. *J Strength Cond Res.*
19 (Published Ahead of Print). doi: 10.1519/JSC.0000000000002048.
- 20 7. Cohen, J. Statistical power analysis for the behavior science. *Lawrance Erlbaum Association,*
21 1988.
- 22 8. Contreras, B, Cronin, J, & Schoenfeld, B. Barbell Hip Thrust. *Strength Cond J.* 33: 58-61.
23 2011.
- 24 9. Contreras, B, Vigotsky, AD, Schoenfeld, BJ, Beardsley, C, & Cronin, J. A comparison of
25 gluteus maximus, biceps femoris, and vastus lateralis electromyographic activity in the back
26 squat and barbell hip thrust exercises. *J Appl Biomech,* 31: 452-458. 2015.
- 27 10. Contreras, B, Vigotsky, AD, Schoenfeld, BJ, Beardsley, C, McMaster, DT, Reyneke, J, &
28 Cronin, J. Effects of a six-week hip thrust versus front squat resistance training program on
29 performance in adolescent males: A randomized-controlled trial. *J Strength Cond Res.* 31:
30 999-1008. 2016.
- 31 11. Cormie, P, McCaulley, GO, Triplett, NT, & McBride, JM. Optimal loading for maximal power
32 output during lower-body resistance exercises. *Med Sci Sports Exerc.* 39: 340. 2007.

12. Crewther, B, Cronin, J & Keogh, J. Possible Stimuli for Strength and Power Adaptation. Acute Mechanical Responses. *Sports Med.* 35: 967-989. 2005.
13. Cronin, J, Ogden, T, Lawton, T, & Brughelli, M. Does Increasing Maximal Strength Improve Sprint Running Performance? *Strength Cond J.* 29: 86-95. 2007.
14. Cronin, J. & Hansen, K. T. Resisted Sprint Training for the Acceleration Phase of Sprinting. *Strength Cond J.* 28: 42 – 51. 2006.
15. Delecluse, C. Influence of Strength Training on Sprint Running Performance: Current Findings and Implications for Training. *Sports Med.* 24: 147–156. 1997.
16. Fonseca, RM, Roschel, H, Tricoli, V, de Souza, EO, Wilson, JM, Laurentino, GC, Aihara, AY, de Souza Leão, AR, & Ugrinowitsch, C. Changes in exercises are more effective than in loading schemes to improve muscle strength. *J Strength Cond Res.* 28: 3085-3092. 2014.
17. Gabbett, T. J. Physiological and anthropometric characteristics of elite women rugby league players. *J Strength Cond Res.* 21: 875-881. 2007.
18. Gomez, JP, Rodriguez, GV, Ara, I, Olmedillas, H, Chavarren, J, González-Henriquez, JJ, Dorado, C, & Calbet, JAL. Role of muscle mass on sprint performance: gender differences? *Eur J Appl Physiol.* 102: 685-694. 2008.
19. Hennessy, L, & Kilty, J. Relationship of the stretch-shortening cycle to sprint performance in trained female athletes. *J Strength Cond Res.* 15: 326-331. 2001.
20. Manson, SA, Brughelli, M, & Harris, NK. Physiological Characteristics of International Female Soccer Players. *J Strength Cond Res.* 28: 308-318. 2014.
21. Mendiguchia, J, Martinez-Ruiz, E, Morin, JB, Samozino, P, Edouard, P, Alcaraz PE, Esparza-Ros, F, and Mendez-Villanueva, A. Effects of hamstring-emphasized neuromuscular training on strength and sprinting mechanics in football players. *Scand J Med Sci Sports.* 25: e621-e629. 2015.
22. Mero, A. Force-time characteristics and running velocity of male sprinters during the acceleration phase of sprinting. *Res Q Exercise Sport.* 59: 94–98. 1988.
23. Meylan, CMP, Cronin, JB, Oliver, JL, Hopkins, WG, & Contreras, B. The effect of maturation on adaptations to strength training and detraining in 11–15-year-olds. *Scand J Med Sci Sports.* 24: e156-e164. 2014.

- 1 24. Morin, JB, Bourdin, M, Edouard, P, Peyrot, N, Samozino, P, & Lacour, JR. Mechanical
2 determinants of 100-m sprint running performance. *Eur J Appl Physiol.* 112: 3921-3930.
3 2012.
- 4 25. Morin, JB, Edouard, P, & Samozino, P. New insights into sprint biomechanics and
5 determinants of elite 100m performance. *New Stud Athlet.* 28: 87-103. 2013.
- 6 26. Morin, JB, Edouard, P, Samozino, P. Technical ability of force application as a determinant
7 factor of sprint performance. *Med Sci Sport Exer.* 43: 1680-1688. 2011.
- 8 27. Nadler, SF, Malanga, GA, DePrince, M, Stitik, TP, & Feinberg, JH. The relationship between
9 lower extremity injury, low back pain, and hip muscle strength in male and female collegiate
10 athletes. *Clin J Sport Med.* 10: 89-97. 2000.
- 11 28. Pearson, SJ, & McMahon, J. Lower Limb Mechanical Properties. *Sports Med.* 42: 929-940.
12 2012.
- 13 29. Peterson, MD, Rhea, MR, & Alvar, BA. Maximizing strength development in athletes: a
14 meta-analysis to determine the dose-response relationship. *J Strength Cond Res.* 18: 377-
15 382. 2004.
- 16 30. Rabita, G, Dorel, S, Slawinski, J, Sàez-de-Villarreal, E, Couturier, A, Samozino, P, & Morin JB.
17 Sprint mechanics in world-class athletes: A new insight into the limits of human locomotion.
18 *Scand J Med Sci Sports.* 25: 583-594. 2015.
- 19 31. Rivière, M, Louit, L, Strokosch, A, & Seitz, LB. Variable resistance training promotes greater
20 strength and power adaptations than traditional resistance training in elite youth rugby
21 league players. *J Strength Cond Res.* 31: 947-955. 2017.
- 22 32. Seitz, LB, Reyes, A, Tran, TT, De Villareal, ES, & Haff, GG. Increases in Lower-Body Strength
23 Transfer Positively to Sprint Performance: A Systematic Review with Meta-Analysis. *Sports*
24 *Med.* 44: 1693-1702. 2014.
- 25 33. Weyand, PG, Sternlight, DB, Bellizzi, MJ, & Wright, S. Faster top running speeds are achieved
26 with greater ground forces not more rapid leg movement. *J Appl Physiol.* 89: 1991-1999.
27 2000.
- 28 34. Yavuz, HU, Erdağ, D, Amca, AM, & Aritan, S. Kinematic and EMG activities during front and
29 back squat variations in maximum loads. *J Sport Sci.* 33: 1058-1066. 2015.
- 30 35. Young, WB. Transfer of strength and power training to sports performance. *Int J Sports*
31 *Physiol Perform.* 1: 74-83. 2006.

36. Zweifel, MB, Vigotsky, AD, Contreras, B, & Simiyu, WWN. Effects of 6-week squat, deadlift, or hip thrust training program on speed, power, agility, and strength in experienced lifters: A pilot study. *J Trainol.* 6: 13-17. 2017.

1 **Table 1.** Pre and post intervention performance data with absolute and percentage differences.

2

<i>Test</i>	Intervention				Control			
	<i>Pre</i>	<i>Post</i>	<i>Absolute Difference</i>	<i>Percentage Difference</i>	<i>Pre</i>	<i>Post</i>	<i>Absolute Difference</i>	<i>Percentage Difference</i>
0-10m (s)	1.80 ± 0.26	1.86 ± 0.23	0.06 ± 0.14	3.92%	1.71 ± 0.27	1.69 ± 0.15	-0.01 ± 0.19	0.19%
10-20m (s)	1.50 ± 0.26	1.48 ± 0.24	-0.01 ± 0.04	-0.76%	1.36 ± 0.13	1.38 ± 0.11	0.02 ± 0.04	1.51%
20-30m (s)	1.42 ± 0.30	1.41 ± 0.25	-0.01 ± 0.07	-0.24%	1.29 ± 0.15	1.32 ± 0.15	0.03 ± 0.05	2.15%
30-40m (s)	1.41 ± 0.33	1.41 ± 0.28	0.00 ± 0.08	0.51%	1.32 ± 0.19	1.30 ± 0.18	-0.01 ± 0.04	-0.76%
Total 40m (s)	6.16 ± 1.15	6.19 ± 0.97	0.03 ± 0.22	0.88%	5.69 ± 0.73	5.73 ± 0.56	0.03 ± 0.21	0.89%
1RM hip thrust (kg)	161.8 ± 50.41	205.9 ± 63.27 **	44.09 ± 21.43	28.52%	164.6 ± 36.71	174 ± 41.88	9.4 ± 11.8	5.43%

Notes: Values represented as mean ± SD; Pre = before training intervention; Post = after training intervention; 0-10m = 0-10m split sprint time; 10-20m= 10-20m split sprint time; 20-30m = 20-30m split sprint time; 30-40m = 30-40m split sprint time; 40m = total 40m sprint time; 1RM = 1 Repetition Maximum.

** Denotes significantly different between time points (pre – post), $p \leq 0.05$

3

1 **Table 2.** Reliability data for all sprint conditions.

2

3

Hip Thrust Intervention Group					Control Group			
Test	CV (%)	Intraclass	95% Confidence Interval		CV (%)	Intraclass	95% Confidence Interval	
		Correlation	95% CI	95% CI		Correlation	95% CI	95% CI
		Coefficient	(lower	(upper		Coefficient	(lower	(upper
		(ICC)	bound)	bound)		(ICC)	bound)	bound)
0-10m	2.3	.967	.913	.990	1.0	.996	.988	.999
10-20m	1.6	.991	.975	.997	1.7	.958	.885	.989
20-30m	1.3	.995	.985	.999	2.4	.931	.820	.981
30-40m	1.6	.995	.986	.998	3.3	.911	.773	.975
40m	1.1	.996	.986	.999	1.5	.977	.937	.994

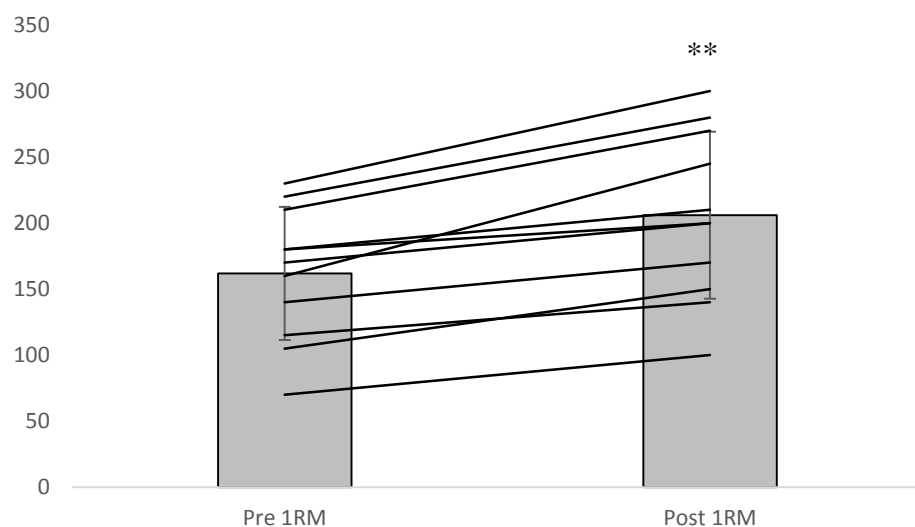


Figure 1. Hip thrust strength training group baseline vs. post testing mean and individual data for 1RM hip thrust (kg).

** denotes significantly different from baseline value ($p < 0.05$)

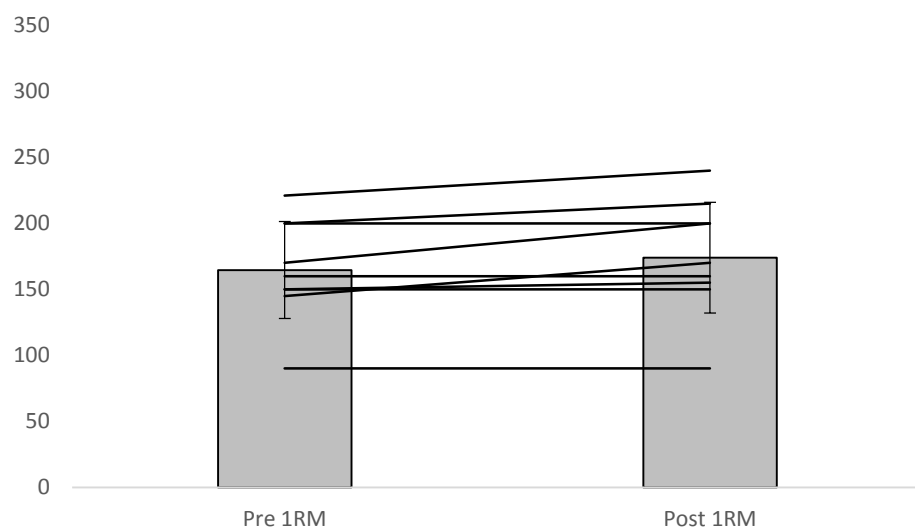


Figure 2. Control group baseline vs. post testing mean and individual data for 1RM hip thrust (kg).